Phosphorus and Potassium Fertilization and Mineral Nutrition of Soybean in Guarico State

By E.F. Casanova

Although soybean yields are improving in Venezuela, current production levels fall far short of the amounts needed to satisfy local feed markets. This research helps to identify best management practices needed for sustained, high yields on Venezuela's acid, low fertility savanna soils.

Venezuela imports around 800,000 tonnes of soybeans every year to be used mainly for swine and poultry production. The largest area planted during the last 15 years was 7,850 ha in 1988, while the average yield for 1986 to 1996 was 1,517 kg/ha (**Figure 1**). These data show how dependent Venezuela is on soybean imports.

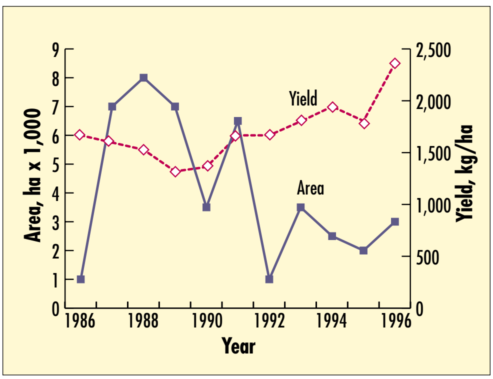

Figure 1. Area harvested and soybean yields in Venezuela (1986-1996).

Agriculture in Guarico state, located in north central Venezuela, has been rapidly developing and several crops, including soybean, are grown successfully. The state's prevalent soils were developed under savanna and have low natural fertility. These soils are acid. The primary plant nutritional limitations are phosphorus (P), potassium (K), nitrogen (N), and calcium (Ca). Other nutrients such as magnesium (Mg), sulfur (S) and zinc (Zn) become limiting when the soil is cultivated for several years. Consequently, sustained agriculture in the region is based on sound liming and fertilizer programs.

A field experiment was conducted during two rainy seasons to evaluate the effect of P and K rates on soybean yield and nutrition.

Materials and Methods

The site was located on a farm at Palo Seco, Guarico state, Venezuela. The test soil was an Oxisol, typical of the savanna soils of the Eastern Llanos of Venezuela. Physical and chemical characteristics of the soil are presented in **Table 1**.

A randomized block design with three replications was used in the field. Variables were: 0, 5, 10, 20, 30, 40, 50, 60, and 70 kg P/ha as triple

Table 1. Soil characterization at Palo Seco, Guarico state, Venezuela.

Sand	Silt	Clay	Texture	pH	Organic matter	P	K	Ca
....	%	....			%	ppm	cmol(+)/kg	
51	29	20	Loam	4.5	1.3	22	0.10	0.05

superphosphate (TSP), and 0, 9, 18, 36, 54, 72, 90, 108, and 135 kg K/ha as potassium chloride (KCl). All P plots received a fixed rate of 108 kg K/ha, and all K plots received a fixed rate of 60 kg P/ha. A basic application of 1,000 kg lime/ha (300 kg Ca/ha) was incorporated in all plots along with 220 kg magnesium sulfate ($MgSO_4$)/ha...40 kg Mg/ha. All the fertilizers were broadcast and plowed under before planting. In both years, soybean seeds (cultivar FP-3) were inoculated at planting with *Bradyrhizobium japonicum*. Nitrogen was also applied at 30 kg/ha during planting to insure adequate N supply while nodules developed and became active.

The uppermost trifoliate leaves were sampled at the R2 plant reproductive stage to evaluate P and K nutritional status of the plant for comparison with the published sufficiency levels in the literature. Harvest was carried out 115 days after planting. Grain yield at 12 percent moisture was recorded.

Results and Discussion

Grain yield responses to P treatments for two years are presented in **Table 2**. A yield response to P is clear in both years, and the best yields were obtained with 70 kg P/ha. Grain yield response to K application is given in **Table 3**. The best grain yields were obtained with 108 kg K/ha in the two years studied.

Foliar P and K concentrations at the R2 plant reproductive stage are presented in **Tables 2** and **3**, respectively. As expected, when P was not applied, foliar P concentrations were at deficient levels in both years. The highest foliar P concentration was reached at 60 kg P/ha in 1997 and 20 kg P/ha in 1998. This difference was likely related to a better rainfall distribution in 1997 and excess moisture in 1998.

In 1997, foliar K concentrations were deficient in the two lowest K treatments while application of 18 kg K/ha produced values within the sufficiency range as reported in published literature. In 1998, all the treatments produced a foliar K concentration within the sufficiency range. Highest

Table 2. Soybean grain yields and foliar P concentration responses to P application rates in field experiments at Palo Seco, Guarico state, Venezuela.

P rates[1]	Soybean yield		P foliar concentration[2]	
	kg/ha		%	
	1997	1998	1997	1998
0	615	700	0.23	0.28
5	814	890	0.26	0.35
10	826	960	0.44	0.35
20	925	1,338	0.44	0.57
30	1,188	1,667	0.46	0.51
40	1,585	2,433	0.46	0.40
50	2,443	2,731	0.44	0.35
60	2,598	2,814	0.50	0.35
70	2,713	2,938	0.50	0.38

[1] All treatments received a blanket application of 108 kg K/ha
[2] Uppermost trifoliate leaves at the R2 plant reproductive stage

Table 3. Soybean grain yields and foliar K concentration responses to K application rates in field experiments at Palo Seco, Guarico state, Venezuela.

K rates[1]	Soybean yield		K foliar concentration[2]	
	kg/ha		%	
	1997	1998	1997	1998
0	914	1,180	1.51	2.27
9	973	1,280	1.58	2.87
18	1,092	1,299	2.34	2.64
36	1,188	1,320	2.36	2.54
54	1,559	2,236	2.66	2.64
72	2,294	2,725	2.62	2.62
90	2,246	2,773	2.71	2.70
108	2,544	3,164	2.25	2.65
135	2,520	2,815	2.21	2.61

[1] All treatments received a blanket application of 60 kg P/ha
[2] Uppermost trifoliate leaves at the R2 plant reproductive stage

concentrations were reached with 90 kg K/ha in both years.

These results suggest that the sufficiency ranges presented in the literature are probably not appropriate for tropical conditions and particularly for the soybean varieties used in Venezuela. Grain yield results obtained in this experiment did not correlate well with foliar nutrient concentrations. Therefore, further research is needed to define the critical levels for soybean grown in Venezuelan environments.

This study also emphasized the importance of seed inoculation with *Bradyrhizobium japonicum* to promote fixation of atmospheric N. Since the majority of these soils do not have a history of soybean cultivation, a small amount of N at planting is also needed to assure adequate supply of N. Future efforts will be needed to commercially produce this inoculant in Venezuela to satisfy the demand of soybean area expansion.

Conclusions

Soybean yields showed a positive response to P and K fertilization in the savanna soils of Venezuela. The treatment combination of 60 kg P/ha and 108 kg K/ha produced the best grain yield of 3,164 kg/ha in 1998. High yielding treatments also produced leaf P and K concentrations within known sufficiency ranges.

Established critical levels for leaf P and K in soybean did not relate well with yields obtained in the two study years. These results suggest that the sufficiency range used to establish the plant nutritional status is probably not appropriate for the tropical conditions and varieties used in Venezuela. Therefore, it will be necessary to conduct additional research in order to define new critical levels for soybean grown in the country.

Data documented with these experiments clearly demonstrate that nutrient and fertilizer management is an important factor to be considered for soybean production in the acid, low fertility soils of the Venezuelan savannas. Careful soil management can sustain high soybean yields to satisfy the needs of Venezuelan poultry and swine production. **BCI**

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Research Notes

India: Optimal Phosphorus Management Strategies for Wheat-Rice Cropping on a Loamy Sand

Researchers evaluated phosphorus (P) management strategies for a wheat-rice rotation, comparing seven P fertilizer treatments for wheat and rice, respectively. Results of the 1990 to 1997 study were as follows:

- Grain yields and seasonal P accumulation were highest with highest P fertilizer rates and remained stable in treatments with P applied to wheat.
- Phosphorus fertilization of rice increased P accumulation by rice, but did not consistently increase yields (because flooding decreased soil P sorption and increased P diffusion, resulting in a higher P supply to rice relative to wheat).
- Phosphorus adsorbed by ion-exchange resin capsules placed in situ was five times greater under rice than under wheat.

Researchers concluded that when both grain and straw were removed from fields, annual application of 32 kg P/ha to wheat, along with 15 kg P/ha to rice, was optimal for achieving short-term economic and long-term agronomic goals. They also pointed out that their results require further study at other sites, at higher rice yield levels and for different straw management. **BCI**

Source: Yadvinder-Singh, A. Dobermann, Bijay-Singh, K.F. Bronson, and C.S. Khind. 2000. Soil Sci. Soc. Am. J. 64: 1413-1422.